Review

The Role of Menthol in Cigarettes as a Reinforcer of Smoking Behavior

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Abstract

Introduction: The World Health Organization has identified several additives such as menthol in the manufacturing of cigarettes to specifically reduce smoke harshness. These additives may have important implications for reinforcing smoking behavior and motivation to quit smoking. The purpose of this paper is to synthesize research related to the role of menthol's sensory characteristics in strengthening the reinforcing effects of nicotine in cigarettes and the impact on nicotine addiction and smoking behavior.

Methods: Research reports from 2002 to 2010 on the addictive potential of menthol cigarettes were reviewed that included qualitative focus groups, self-reports and biomarkers of nicotine dependence, human laboratory, and epidemiological studies.

Results: Positive sensory effects of menthol cigarette use were identified via reports of early smoking experiences and as a potential starter product for smoking uptake in youth. Menthol cigarettes may serve as a conditioned stimulus that reinforces the rewarding effects of smoking. Nicotine dependence measured by shorter time-to-first cigarette upon waking was increased with menthol cigarette use in most of the studies reviewed. Smoking quit rates provide additional indicators of nicotine dependence, and the majority of the studies reviewed provided evidence of lower quit rates or higher relapse rates among menthol cigarette smokers.

Conclusions: The effects of menthol cigarette use in increasing the reinforcing effects of nicotine on smoking behavior were evidenced in both qualitative and quantitative empirical studies. These findings have implications for enhanced prevention and cessation efforts in menthol smokers.

Introduction

It is well documented that tobacco use is highly addictive. Nicotine is the psychoactive substance in tobacco that produces tobacco addiction and serves as a potent and powerful reinforcer in both humans and animals (Corrigall, 1999; Goldberg & Henningfield, 1988). While nicotine is the primary psychoactive

component that makes tobacco addictive, the World Health Organization (WHO, 2007) in their technical report series has identified several additives such as menthol in the manufacturing of cigarettes to specifically reduce the smoke harshness, leading the smoker to possibly take in more toxic and dependence-causing smoke constituents. These additives may alter the attractiveness and/or ease of use of the product and contribute to the perception that cigarettes are less harmful (Davis, McClave-Regan, Rock, Kruger, & Garrett, 2010; Unger, Allen, Leonard, Wenten, & Boley Cruz, 2010). These additives may also have important implications for addiction risk and motivation to quit. A recommendation by WHO was to regulate "contents and designs that contribute to consumer appeal and palatability" since they contribute to "effects on tobacco use initiation, patterns of use, product selection, and persistence of use." They further recommended the importance of educating menthol cigarette smokers that additives "are masking the harshness of cigarette emissions and allowing them to bypass the body's normal defense mechanisms for preventing exposure to detrimental substances."

Prior to 1970, the tobacco industry used few additives in U.S. cigarettes (Bates, Jarvis, & Connolly, 1999), while additives currently represent about 10% of cigarette weight (Browne, 1990; Keithly, Ferris, Wayne, Cullen, & Connolly, 2005). A list of 599 tobacco additives was released in 1994 by the major tobacco companies with more than 100 having pharmacological actions (Rabinoff, Caskey, Rissling, & Park, 2007). Unlike most additives, menthol has been used in cigarettes since the mid 1920s (Gardiner, 2004). Since the 2002 Conference on Menthol Cigarettes, publications referencing tobacco industry documents related to menthol additives have increased as well as research regarding the sensory effects of menthol in cigarettes. While there has been increasing research to determine if menthol increases nicotine addiction, the fundamental question that should be asked is whether menthol enhances the reinforcing effects of nicotine in cigarettes, thus increasing the potential for smokers to become addicted to cigarettes.

The purpose of this paper is to synthesize research since the 2002 First Conference on Menthol Cigarettes related to the role of menthol's sensory effects in strengthening the reinforcing effects of nicotine in cigarettes and the impact on smoking behavior. Empirical studies on the sensory effects of menthol in

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cigarettes and the relationship of menthol cigarettes and nicotine addiction are included.

Empirical studies were identified using combinations of the following search terms: menthol cigarettes, addiction, smoking cessation, sensory, and taste. Non-English and nonhuman studies were excluded. The timeframe was 2002–2010 to highlight research since the First Conference on Menthol Cigarettes in 2002. This is not intended to be an exhaustive review.

Reinforcing Sensory Effects of Menthol in Cigarettes

As stated above, nicotine is a powerful reinforcer that leads to continuous tobacco use and addiction. Menthol may increase the strength or sensory impact of nicotine, thus increasing the reinforcing effects of nicotine in tobacco (Ahijevych & Garrett, 2004). The sensory effects of menthol in cigarettes are critical in understanding the smoker's subjective experience and how that can contribute to the reinforcing effects of smoking. Internal tobacco industry documents have shown that sensory impact is enhanced when small concentrations of menthol are combined with nicotine and depressed with larger concentrations or after extended exposure to menthol (Henningfield et al., 2003). Furthermore, a review of industry documents found that tobacco companies have manipulated the sensory characteristics of cigarettes, including menthol content to facilitate smoking initiation and nicotine dependence (Kreslake, Ferris Wayne, & Connolly, 2008).

A number of studies have revealed that smokers of menthol cigarettes report smoking these cigarettes because of the characteristic cool minty taste compared with nonmenthol cigarettes (Hymowitz, Mouton, & Edkholdt, 1995; Richter, Beistele, Pederson, & O'Hegarty, 2008). These findings suggest that it is particularly important to understand the influence of menthol as a cigarette additive from the perspective of the menthol cigarette smoker. Illustrative focus group, human laboratory, and cross-sectional studies are summarized below that describe the salience of this additive in the words of menthol cigarette smokers.

Finkenauer, Pomerleau, Snedecor, and Pomerleau (2009) assessed retrospective reports of early smoking experiences among Black ($n = 48$) and Caucasian ($n = 155$) current smokers in which 90% of Black and 25% of Caucasian smokers smoked menthol cigarettes. In early experiences with smoking, Blacks experienced higher levels of global pleasure sensations, a pleasurable "rush or buzz," and more relaxation compared with Caucasian smokers. In addition, Black smokers reported marginally lower rates of dizziness and less difficulty inhaling than Caucasian smokers. While analyses were not reported by menthol/nonmenthol cigarettes, nearly all Blacks smoked mentholated cigarettes, suggesting that menthol cigarettes may have produced positive sensory effects that contributed to the appeal of the early smoking experience in Blacks (for empirical studies summary, see Supplementary Table 1).

Richter et al. (2008) assessed sensory perceptions of menthol cigarettes among Black focus group participants ($n = 54$), of whom 87% smoked menthol cigarettes. A theme emerged that taste was the main reason for smoking a particular brand

and was the overwhelming reason for choosing menthol rather than nonmenthol cigarettes. Participants in this study described the taste of menthol cigarettes as "being able to taste them better than a nonmenthol cigarette that requires you to pull on it," "more enjoyable than nonmenthol cigarettes," and "tasting like a peppermint patty." These findings are consistent with those from a previous report in which Black smokers thought that menthol cigarettes were less harsh than nonmenthol cigarettes, easier to inhale, and could be inhaled more deeply (Hymowitz et al., 1995).

In comparison, in a small laboratory-based study, persons smoking menthol cigarettes ($n = 18$) did not differ from those smoking nonmenthol cigarettes ($n = 18$) on subjective responses of liking, puff satisfaction, and strength (Pickworth, Moolchan, Berlin, & Murty, 2002). In the protocol, menthol cigarette smokers smoked three menthol cigarettes and nonmenthol cigarette smokers smoked three nonmenthol cigarettes. Participants each smoked one of three cigarettes at 45-min intervals: a high- and a low nicotine-yield research cigarette as well as a commercial cigarette, which was not the usual brand of the participant. There was a significant group (menthol and nonmenthol smokers) by cigarette interaction on two of five subjective cigarette evaluation responses. Specifically, increased satisfaction and higher craving relief occurred in the high nicotine-yield research cigarettes in the nonmenthol group compared with the high nicotine-yield research cigarettes in the menthol group. No significant interactions occurred on psychological reward, negative effects, and peripheral sensation on cigarette evaluation. Ninety-four percent of the menthol cigarette group was Black, while 83% of the nonmenthol cigarette group was Caucasian. Similar to other studies, the overlap of menthol cigarettes and race makes it difficult to separate the unique contributions of these variables.

Rose and Behm (2004) conducted a 2-week precession treatment study designed to promote extinction of the responses to rewarding cigarette cues. Pharmacological treatments included transdermal nicotine and/or the nicotinic acetylcholine receptor antagonist mecamylamine, while a behavioral manipulation included switching to cigarettes having a different menthol flavor from their usual brand. Different effects were noted with manipulation of the menthol content of cigarettes smoked during the 2-week treatment depending on whether participants were habitual menthol ($n = 7$) or nonmenthol ($n = 17$) cigarette smokers. In menthol smokers who were switched to nonmenthol cigarettes (removing the menthol cue) for the 2-week period, extinction of reward ratings for their usual menthol brand test cigarette did not occur. On the other hand, nonmenthol cigarette smokers who were switched to menthol cigarettes (menthol cue) for the 2-week period showed progress of extinction of nonmenthol cigarette cues in their test cigarette. Authors noted that changing the menthol cigarette cue had a significant influence on reward ratings and suggests that menthol is a major component of the conditioned reward.

Taste-altering effects of food and beverage on cigarette palatability were assessed in cigarette smokers ($N = 209$) with 46.8% smoking mentholated cigarettes (McClernon, Westman, Rose, & Lutz, 2007). Forty-five percent of participants identified fruits and vegetables, dairy beverages, and dairy food products as worsening the taste of cigarettes, while 69% reported caffeinated

and alcoholic beverages and meat as enhancing the taste of cigarettes. Interestingly, a lesser likelihood of reporting taste worsening or enhancement with food or beverages occurred among mentholated cigarette smokers. Authors proposed that menthol may enhance dependence in these smokers by “evening out” their smoking experience. Future laboratory-based experiments could build on these qualitative data.

In summary, the reinforcing sensory effects of menthol cigarettes have been examined from multiple perspectives. Descriptions of positive early smoking experiences with menthol cigarettes suggest that menthol cigarettes may facilitate smoking initiation. The taste of menthol in cigarettes may serve as a reinforcer of smoking behavior as “taste” was expressed overwhelmingly as the reason for smoking this type of cigarette among Black focus group participants. Menthol appears to increase the rewarding or reinforcing effects of nicotine, thus possibly increasing the likelihood of becoming dependent on nicotine.

The following sections will describe the impact of menthol’s sensory effects on measures of nicotine dependence, including the Fagerström Test for Nicotine Dependence (FTND), smoking behaviors such as the FTND “time-to-first” cigarette, and smoking cessation.

Menthol Cigarettes and Measures of Nicotine Addiction

The FTND and the FTND time-to-first cigarette (TTF) items are commonly used measures in the assessment of nicotine dependence (Heatherton, Kozlowski, Frecker, Rickert, & Robinson, 1989). While not all conclusive, the majority of studies reviewed below that have used these measures have shown a relationship between menthol cigarette use and nicotine dependence.

Participants in the Community Intervention Trial for Smoking Cessation (COMMIT) in 1988 were assessed on the relationship of their type of cigarette and TTF with 13,268 current smokers 25–64 years of age responding to a telephone survey. Individuals were enrolled in a smoking cessation trial and trying to quit smoking. Follow-up interviews were conducted in 1993. In the total sample, 24% smoked menthol cigarettes. Time-to-first cigarette was defined as <10 min and 10+ min after waking. After controlling for covariates, menthol cigarette smokers were 1.16 times more likely to report TTF >60 min compared with the reference of <10 min; thus, there were no significant differences by menthol status on shorter TTF (Hyland, Garten, Giovino, & Cummings, 2002). These data suggest somewhat lower nicotine dependence in individuals smoking menthol cigarettes.

On the other hand, data from the 2004 National Youth Tobacco Survey were used to examine measures of nicotine dependence among adolescent menthol and nonmenthol cigarette smokers in a nationally representative sample of 1,345 current established smokers in grades 9–12 (Wackowski & Delnevo, 2007). Nicotine dependence was operationalized as self-reported needing a cigarette within less than 1 hr from the previous cigarette smoked. Approximately 46% of the sample was menthol cigarette smokers. Menthol cigarette smokers had 2.6 and

1.6 greater odds than nonmenthol smokers for reporting that they could go for less than 1 hr before feeling like they needed a cigarette and experienced cravings after not smoking for a while, respectively. The analysis controlled for gender, race, number of days smoked in the past thirty days, and number of cigarettes smoked per day. The authors concluded that menthol cigarette smoking was significantly associated with two dependence measures and may be more addictive than nonmenthol cigarettes in young smokers.

These findings are consistent with findings by Hersey et al. (2006) of current middle school and high school smokers in the 2000 and 2002 National Youth Tobacco Surveys. Menthol cigarette smokers ($n = 1,552$; 48.5%) in the sample were younger newer smokers than those smoking nonmenthol cigarettes ($n = 1,650$; 51.5%). Nicotine dependence was assessed with the Nicotine Dependence Scale for Adolescents (Nonnemaker et al., 2004), which included TTF and experiencing cravings. Teens who were smokers of menthol cigarettes had significantly higher odds of being above the median on nicotine dependence (odds ratio [OR] = 1.45, $p = .006$) compared with those who did not smoke menthol cigarettes. Authors concluded that menthol cigarettes seem to be a starter product that may be associated with smoking uptake by youth.

Similarly, greater smoking urgency was identified among adolescent menthol smokers compared with nonmenthol smokers (Collins & Moolchan, 2006). Data were collected in telephone interviews in which adolescent smokers were applying to a cessation treatment study that yielded a sample of 531 menthol smokers and 41 nonmenthol smokers, with 46.9% being Black. Forty-five percent of menthol smokers smoked within the first 5 min of the day versus 29% of nonmenthol smokers. Despite a lack of group differences in cigarettes per day or FTND scores, adolescent menthol cigarette smokers had a significantly shorter time-to-first cigarette of the day.

Among adult Black smokers ($n = 600$) in a clinical trial assessing the efficacy of sustained-release bupropion for smoking cessation, 78.5% were menthol cigarette smokers. Findings indicated that menthol smokers were significantly more likely to smoke their first cigarette within 30 min of waking compared with nonmenthol smokers, 81.7% versus 69.8%, respectively (Okuyemi et al., 2003). Both groups had similar FTND scores.

Furthermore, in a community-based cross-sectional study of 525 adult smokers of which 54% were menthol cigarette smokers, Muscat, Chen, et al. (2009) reported an increased risk of smoking the first cigarette within 30 min of waking among menthol cigarette smokers (OR = 2.1, CI = 1.0–3.8). However, the relationship between nicotine dependence and cigarette type was not significant when measured by the FTND. The racial/ethnic breakdown by menthol categories in this adult sample was imbalanced with 90% and 82% of Black men and women, respectively, smoking menthol cigarettes, while only 25% and 31% of White men and women, respectively, reported menthol cigarette use. As a result, there was a considerable overlap of menthol cigarette preference and race.

In summary, nicotine dependence as measured by TTF was significantly associated with menthol cigarette use in five of the six studies above (Collins & Moolchan, 2006; Hersey et al., 2006; Muscat, Chen, et al. (2009); Okuyemi et al., 2003;

Wackowski & Delnevo, 2007), while nicotine dependence was reported as not being significantly associated with menthol cigarette use in the three studies that used FTND (Collins & Moolchan, 2006; Muscat et al., 2009; Okuyemi et al., 2003).

Smoking quit rates are also used as an indicator of nicotine dependence with lower quit rates typically associated with higher nicotine dependence. As with nicotine dependence measures, while not all conclusive, a number of studies reviewed here report an association between menthol cigarette use and lower smoking quit rates.

In a large study of persons attending a tobacco treatment clinic incorporating nicotine replacement medication and counseling, 1,688 participants were followed at 4 weeks and 6 months posttreatment in the timeframe of 2001–2005 (Gandhi, Foulds, Steinberg, Lu, & Williams, 2009). Forty-six percent of the sample smoked menthol cigarettes. There was a two-way interaction between race/ethnicity and menthol/nonmenthol cigarettes on quit rates. Black menthol smokers were significantly less likely to quit than Black nonmenthol smokers. Quit rates for Black menthol and nonmenthol cigarette smokers at 4-week follow-up were 30% and 54%, respectively and 18% and 36% at 6-month follow-up, respectively ($p = .001$). Similarly, Latino menthol cigarette smokers had lower quit rates than Latino nonmenthol cigarette smokers at 4-week follow-up, 23% and 50%, respectively ($p = .001$), as well as lower quit rates at 6-month follow-up, 11% and 28%, respectively ($p = .009$). Interestingly, data regarding awakening at night to smoke were collected, and menthol smokers had a significantly higher frequency of nighttime smoking compared with nonmenthol smokers. This variable is another potential indicator of nicotine dependence.

In contrast, there was no difference in smoking cessation success with menthol or nonmenthol cigarette use in the Lung Health Study (LHS) of over 5,887 smokers aged 35–60 years who had early evidence of obstructive lung impairment (Murray, Connell, Skeans, & Tashkin, 2007). Enrollment occurred from 1986 to 1989. About 20% of the sample reported smoking menthol cigarettes, which remained relatively stable over the 5-year follow-up period. The proportion of continuing smokers was similar over 5 years ranging from 55.9% to 57.3% across sex by menthol/nonmenthol cigarette type groups. Those who were intermittent smokers at annual data collection over the 5-year period ranged from 26.0% to 30.4% across groups. Sustained quitters ranged from 13.8% to 17.2%. There were no differences by type of cigarette smoked.

Comparison of findings of the Gandhi et al. (2009) clinic-based study and the Murray et al. (2007) LHS is complicated by variation in sample composition with 46% versus 20% being menthol cigarette smokers in the clinic-based study versus LHS, respectively. In addition, a difference in diversity of the samples was noted with 48.5% non-White in the clinic-based study compared with 3.2% non-White in the LHS, limiting generalizability in the latter. Furthermore, different tobacco dependence treatment modalities were used in the two studies.

Cropsey et al. (2009) reported no effect of menthol cigarettes on bioconfirmed smoking cessation in 233 female prisoners in the treatment arm of a two-group study. There was a treatment by race effect with higher quitting among Whites. While about half of the sample was Black, the distribution of menthol cigarette smokers was unbalanced with 49% of European Americans

smoking menthol cigarettes compared with 95% of Blacks making it difficult to separate ethnicity and menthol/nonmenthol cigarette brand effects.

Five Veterans Affairs medical center pharmacy databases were used to identify 1,343 smokers who had been prescribed nicotine replacement therapy or bupropion 2 years earlier to include in a follow-up survey to determine smoking cessation among menthol/nonmenthol cigarette brand users using measures of self-reported smoking abstinence posttreatment (Fu et al., 2008). Menthol cigarette smokers comprised 25% of the sample, which was predominantly men (94%), White (73%), and older (mean = 56 years). In this somewhat unique sample, menthol cigarette use was not associated with lower smoking cessation.

Okuyemi, Faseru, Sanderson Cox, Bronars, and Ahluwalia (2007) compared smoking abstinence rates for nonmenthol and menthol cigarette smokers among 755 Blacks in a double-blind, placebo-controlled randomized trial examining placebo and nicotine gum. All participants were light smokers with a rate of ≤ 10 cigarettes/day, and 81.7% smoked menthol cigarettes. At 26 weeks postrandomization, nonmenthol smokers were more likely to quit than menthol cigarette smokers, 18.8% and 11.2%, respectively ($p = .015$).

Data from the 2005 U.S. National Health Interview Survey were used to examine the relationship between race/ethnicity, menthol smoking, and cessation in a nationally representative sample of 7,815 adults who were current and former cigarette smokers and had made a quit attempt (Gundersen, Delnevo, & Wackowski, 2009). The proportion of the total sample who were menthol cigarette smokers was 26.5%. Findings indicated that the association between menthol smoking and cessation differed between Whites and Blacks and Whites and Hispanics. Non-White menthol smokers were significantly less likely to have quit smoking (adjusted odds ratio [AOR] = 0.55, $p < 0.01$) compared with their nonmenthol smoking counterparts. In contrast, among Whites, menthol smokers were more likely to be former smokers than nonmenthol smokers (AOR = 1.17, $p < 0.05$).

In the Coronary Artery Risk Development in Young Adults (CARDIA) Study, smoking cessation behavior and risk factors for coronary artery disease were measured from 1985 to 2000 among 1,544 smokers aged 18–30 years at enrollment. Among Blacks, 89% preferred menthol cigarettes compared with 29% of European Americans (Pletcher et al., 2006). While there were no differences in cessation rates by cigarette type, there was a significant increase in relapse risk among menthol versus nonmenthol cigarette smokers (OR = 1.89, $p = .009$).

In a secondary analysis of a bupropion clinical trial with 600 Black smokers, nonmenthol smokers less than 50 years of age were more likely to have quit smoking (OR = 2.0, CI = 1.03–3.95) at 6 weeks postenrollment than menthol cigarette smokers (Okuyemi et al., 2003). The sample was composed of 78.5% menthol cigarette smokers and 22% nonmenthol smokers.

In summary, five of these eight studies assessing smoking cessation and menthol cigarette use provide evidence of lower quit rates or higher relapse rates among menthol cigarette smokers. Studies with negative findings were with unique samples of female prisoners, male veterans, and individuals with chronic lung impairment.

Discussion

The sensory effects of menthol cigarettes in increasing the reinforcing effects of nicotine in cigarettes was evidenced in studies that investigated the qualitative sensory effects of menthol cigarettes, subjective measures of menthol cigarette use on nicotine dependence, and the impact of menthol cigarette use on smoking cessation. The findings reviewed in this paper are consistent with those from a survey of the tobacco industry documents that focused on the effects of menthol in cigarettes (Wayne & Connolly, 2004). A Philip Morris study reported that “perceived impact seems to vary as a function of the delivery levels of menthol and/or nicotine in smoke” (Gullotta, Hayes, & Martin, 1989). In nonmenthol cigarettes, impact is dependent on nicotine delivery, while in menthol cigarettes, menthol delivery contributes to sensory perceptions of the smoke in the mouth and throat. Another Philip Morris study reported that higher strength ratings were observed with combined menthol and nicotine deliveries compared with nicotine delivery alone (Dunn, Jones, Martin, & Schori, 1975).

Menthol’s sensory effects may serve as a conditioned stimulus increasing the reinforcing effects of nicotine in menthol cigarette smokers, thus increasing the addiction potential of menthol cigarettes. Because the findings reviewed showed differences in the association of menthol cigarette use with measures of nicotine dependence using the TTF and FTND, implications for assessing nicotine dependence among menthol cigarette smokers should be considered. Given that Black and Hispanic/Latino smokers report smoking fewer cigarettes per day (Caraballo et al., 1998), indices such as awakening at night to smoke and TTF may be more appropriate markers of dependence than daily cigarette consumption as used in the FTND (Gandhi et al., 2009). Furthermore, TTF has been reported as a better predictor of plasma cotinine concentrations than cigarettes per day or FTND (Muscat, Stellman, Caraballo, & Richie, 2009). Assessment of nicotine dependence among persons smoking fewer cigarettes per day is especially relevant in clinical practice when determining appropriate levels of smoking cessation pharmacotherapy.

WHO (2007) has recommended the regulation of contents and designs of cigarettes that contribute to consumer appeal and palatability. They have further recommended the importance of educating menthol cigarette smokers that additives are masking the harshness of cigarette emissions and allowing them to bypass the body’s normal defense mechanisms for preventing exposure to detrimental substances. Public health messages regarding the potential masking effects of menthol in cigarettes are critical since use of menthol cigarettes may increase exposure to harmful smoke constituents in cigarettes as well as increase the addiction potential in users of this product.

Supplementary Material

Supplementary Table 1 can be found online at <http://www.ntr.oxfordjournals.org>

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Declaration of Interests

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References

- Ahijevych, K., & Garrett, B. E. (2004). Menthol pharmacology and its potential impact on cigarette smoking behavior. *Nicotine & Tobacco Research*, 6, S17–S28. doi:10.1080/14622200310001649469
- Bates, C., Jarvis, M., & Connolly, G. (1999). Tobacco additives: Cigarette engineering and nicotine addiction. Bates no. 83452276. Retrieved from <http://old.ash.org.uk/html/regultion/html/additives.html>
- Browne, C. L. (1990). *The design of cigarettes* (3rd ed.). Charlotte, NC: Filter Products Division, Celanese Corp.
- Caraballo, R. S., Giovino, G. A., Pechacek, T. G., Mowery, P. D., Richter, P. A., & Strauss, W. J. (1998). Racial and ethnic differences in serum cotinine levels of cigarette smokers: Third National Health and Nutrition Examination Survey. *Journal of the American Medical Association*, 280, 135–139.
- Collins, C. C., & Moolchan, E. T. (2006). Shorter time to first cigarette of the day in menthol adolescent cigarette smokers. *Addictive Behaviors*, 31, 1460–1464. doi:10.1016/j.addbeh.2005.10.001
- Corrigall, W. A. (1999). Nicotine self-administration in animals as a dependence model. *Nicotine & Tobacco Research*, 1, 11–20.
- Cropsey, K. L., Weaver, M. F., Eldridge, G. D., Villaobos, G. C., Best, A. M., & Stitzer, M. L. (2009). Differential success rates in racial groups: Results of a clinical trial of smoking cessation among female prisoners. *Nicotine & Tobacco Research*, 11, 690–697. doi:10.1093/ntr/ntp051
- Davis, S. P., McClave-Regan, A. K., Rock, V. J., Kruger, J., & Garrett, B. E. (2010). Perceptions of menthol cigarette use among U.S. adults: Findings from the 2009 HealthStyles Survey. *Nicotine & Tobacco Research*, 12(Suppl. 2), S125–S135. doi:10.1093/ntr/NTQ205
- Dunn, W. L., Jones, B. W., Martin, P. G., & Schori, T. R. (1975). Menthol cigarette preferences on Blacks and Whites (mn-3). Philip Morris. Bates No.2062951249–2062951265. Retrieved from http://tobaccodocuments.org/product_desin/2062951249-1265.html
- Finkenauer, R., Pomerleau, C. S., Snedecor, S. M., & Pomerleau, O. F. (2009). Race differences in factors relating to smoking initiation. *Addictive Behaviors*, 34, 1056–1059. doi:10.1016/j.addbeh.2009.06.006
- Fu, S. S., Okuyemi, K. S., Partin, M. R., Ahluwalia, J. S., Nelson, D. B., Clthier, B. A., et al. (2008). Menthol cigarettes and smoking cessation during an aided quit attempt. *Nicotine & Tobacco Research*, 10, 457–462. doi:10.1080/14622200801901914

- Gandhi, K. K., Foulds, J., Steinberg, M. B., Lu, S-E, & Williams, J. M. (2009). Lower quit rates among African American and Latino menthol cigarette smokers at a tobacco treatment clinic. *International Journal of Clinical Practice*, 63, 360–367. doi:10.1111/j.1742-1241.2008.01969
- Gardiner, P. S. (2004). The African Americanization of menthol cigarette use in the United States. *Nicotine & Tobacco Research*, 6, S55–S65. doi:10.1080/14622200310001649478
- Goldberg, S. R., & Henningfield, J. E. (1988). Reinforcing effects of nicotine in humans and experimental animals responding under intermittent schedules of IV drug injection. *Pharmacology, Biochemistry and Behavior*, 30, 227–234.
- Gullotta, F. P., Hayes, C. S., & Martin, B. R. (1989). Prep study on menthol/nicotine interactions. *Philip Morris*, Bates No. 2023062681. Retrieved from http://tobaccodocuments.org/product_design/2023062681.html
- Gundersen, D., Delnevo, C., & Wackowski, O. (2009). Exploring the relationship between race/ethnicity, menthol smoking, and cessation, in a nationally representative sample of adults. *Preventive Medicine*, 49, 553–557. doi:10.1016/j.ypmed.2009.10.003
- Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., Rickert, W., & Robinson, J. (1989). Measuring the heaviness of smoking: Using self-reported time to the first cigarette of the day and number of cigarettes smoked per day. *British Journal of Addiction*, 84, 791–799.
- Henningfield, J. E., Benowitz, N. L., Ahijevych, K., Garrett, B. E., Connolly, G. N., & Ferris Wayne, G. (2003). Does menthol enhance the addictiveness of cigarettes? An agenda for research. *Nicotine & Tobacco Research*, 5, 9–11. doi:10.1080/1462220031000070543
- Hersey, J. C., Ng, S. W., Nonnemaker, J. M., Mowery, P., Thomas, K. Y., Vilsaint, M. C., et al. (2006). Are menthol cigarettes a starter product for youth? *Nicotine & Tobacco Research*, 8, 403–413. doi:10.1080/14622200600670389
- Hyland, A., Garten, S., Giovino, G. A., & Cummings, K. M. (2002). Mentholated cigarettes and smoking cessation: Findings from COMMIT Community Intervention Trial for Smoking Cessation. *Tobacco Control*, 11, 135–139. doi:10.1136/tc.11.2.135
- Hymowitz, N., Mouton, C., & Edkholdt, H. (1995). Menthol cigarette smoking in African Americans and whites. *Tobacco Control*, 4, 194–195.
- Keithly, L., Ferris Wayne, G., Cullen, D. M., & Connolly, G. N. (2005). Industry research on the use and effects of levulinic acid: A case study in cigarette additives. *Nicotine & Tobacco Research*, 7, 761–771. doi:10.1080/14622200500259820
- Kreslake, J. M., Ferris Wayne, G., & Connolly, G. N. (2008). The menthol smoker: Tobacco industry research on consumer sensory perception of menthol cigarettes and its role in smoking behavior. *Nicotine & Tobacco Research*, 10, 705–715. doi:10.1080/14622200801979134
- McClernon, F. J., Westman, E. C., Rose, J. E., & Lutz, A. M. (2007). The effects of foods, beverages, and other factors on cigarette palatability. *Nicotine & Tobacco Research*, 9, 505–510. doi:10.1080/14622200701243177
- Murray, R. P., Connett, J. E., Skeans, M. A., & Tashkin, D. P. (2007). Menthol cigarettes and health risks in Lung Health Study data. *Nicotine & Tobacco Research*, 9, 101–107. doi:10.1080/14622200601078418
- Muscat, J. E., Chen, G., Knipe, A., Stellman, S. D., Lazarus, P., & Richie, J. P., Jr. (2009). Effects of menthol on tobacco smoke exposure, nicotine dependence and NNAL glucuronidation. *Cancer Epidemiology Biomarkers Prevention*, 18, 35–41. doi:10.1158/1055-9965.EPI-08-0744
- Muscat, J. E., Stellman, S. D., Caraballo, R. S., & Richie, J. P., Jr. (2009). Time to first cigarette after waking predicts cotinine levels. *Cancer Epidemiology Biomarkers Prevention*, 18, 3415–3420. doi:10.1158/1055-9965.EPI-09-0737
- Nonnemaker, J. M., Mowery, P. D., Hersey, J. C., Mimsch, C. T., Farelly, M. C., Messeri, P., et al. (2004). Measurement properties of a nicotine dependence scale for adolescents. *Nicotine & Tobacco Research*, 6, 295–301. doi:10.1080/14622200600670389
- Okuyemi, K. S., Ahluwalia, J. S., Ebersole-Robinson, M., Catley, D., Mayo, M. S., & Resnicow, K. (2003). Does menthol attenuate the effect if bupropion among African American smokers? *Addiction*, 98, 1387–1393. doi:10.1046/j.1360-0443.2003.00443
- Okuyemi, K. S., Faseru, B., Sanderson Cox, L., Bronars, C. A., & Ahluwalia, J. S. (2007). Relationship between menthol cigarettes and smoking cessation among African American light smokers. *Addiction*, 102, 1979–1986. doi:10.1111/j.1360-0443.2007.02010
- Pickworth, W. B., Moolchan, E. T., Berlin, I., & Murty, R. (2002). Sensory and physiologic effects of menthol and nonmenthol cigarettes with differing nicotine delivery. *Pharmacology, Biochemistry, and Behavior*, 71, 55–61. doi:10.1016/S0091-3057(01)00623-2
- Pletcher, M. J., Hulley, B. J., Houston, T., Kiefe, C. I., Benowitz, N., & Sidney, S. (2006). Menthol cigarettes, smoking cessation, atherosclerosis, and pulmonary function. *Archives of Internal Medicine*, 166, 1915–1922.
- Rabinoff, M., Caskey, N., Rissling, A., & Park, C. (2007). Pharmacological and chemical effects of cigarette additives. *American Journal of Public Health*, 97, 1981–1989. doi:10.2105/AJPH.2005.078014
- Richter, P., Beistele, D., Pederson, L., & O’Hegarty, M. (2008). Small-group discussions on menthol cigarettes: Listening to adult African American smokers in Atlanta, Georgia. *Ethnicity & Health*, 13, 171–182. doi:10.1080/13557850701784694
- Rose, J. E., & Behm, F. M. (2004). Extinguishing the rewarding value of smoke cues: Pharmacological and behavioral treatments. *Nicotine & Tobacco Research*, 6, 523–532. doi:10.1080/14622200410001696501
- Unger, J. B., Allen, B., Leonard, E., Wenten, M., & Boley Cruz, T. (2010). Menthol and non-menthol cigarette use among Black smokers in Southern California. *Nicotine & Tobacco Research*, 12, 398–407. doi:10.1093/ntr/ntq016

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Wackowski, O., & Delnevo, C. D. (2007). Menthol cigarettes and indicators of tobacco dependence among adolescents. *Addictive Behaviors*, 32, 1964–1969. doi:10.1016/j.addbeh.2006.12.023

Wayne, G. F., & Connolly, G. N. (2004). Application, function, and effects of menthol in cigarettes: A survey of tobacco

industry documents. *Nicotine & Tobacco Research*, 6, S43–S54.

World Health Organization. (2007). Contents and design features of tobacco products: Their relationship to dependence potential and consumer appeal. *Technical Report Series*, 945, 7–23.